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P H I L O S O P H I C A L
T R A N S A C T I O N S.

I. *An Account of an artificial Spring of Water.* By Erasmus Darwin, M. D. F. R. S.

Read November 4, 1784.

To the President and Fellows of the Royal Society.

GENTLEMEN,

Derby, July 16, 1784.

CONFIDENT that every atom which may contribute to increase the treasury of useful knowledge, which you are so successfully endeavouring to accumulate, will be agreeable and interesting to the Society, I send you an account of an artificial spring of water, which I produced last summer near the side of the river Darwent in Derby.

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Near my house was an old well, about one hundred yards from the river, and about four yards deep, which had been many years disused on account of the badness of the water, which I found to contain much vitriolic acid, with, at the same time, a slight sulphureous smell and taste; but did not carefully analyse it. The mouth of this well was about four feet above the surface of the river; and the ground, through which it was sunk, consisted of a black, loose, moist earth, which appeared to have been very lately a morass, and is now covered with houses built upon piles. At the bottom was found a bed of red marl, and the spring, which was so strong as to give up many hogheads in a day, oozed from between the morass and the marl: it lay about eight feet beneath the surface of the river, and the water rose within two feet of the top of the well.

Having observed that a very copious spring, called Saint Alkmund's well, rose out of the ground about half a mile higher on the same side of the Darwent, the level of which I knew by the height of the intervening wier to be about four or five feet above the ground about my well; and having observed, that the higher lands, at the distance of a mile or two behind these wells, consisted of red marl like that in the well; I concluded, that, if I should bore through this stratum of marl, I might probably gain a water similar to that of St. Alkmund's well, and hoped that at the same time it might rise above the surface of my old well to the level of St. Alkmund's.

With this intent a pump was first put down for the purpose of more easily keeping dry the bottom of the old well, and a hole about two and an half inches diameter was then bored about thirteen yards below the bottom of the well, till some sand was brought by the auger. A wooden pipe, which

which was previously cut in a conical form at one end, and armed with an iron ring at the other, was driven into the top of this hole, and stood up about two yards from the bottom of the well, and being furrounded with well-rammed clay, the new water ascended in a small stream through the wooden pipe.

Our next operation was to build a wall of clay against the morassy sides of the well, with a wall of well-bricks internally, up to the top of it. This completely stopped out every drop of the old water; and, on taking out the plug which had been put in the wooden pipe, the new water in two or three days rose up to the top, and flowed over the edges of the well.

Afterwards, to gratify my curiosity in seeing how high the new spring would rise, and for the agreeable purpose of procuring the water at all times quite cold and fresh, I directed a pipe of lead, about eight yards long, and three-quarters of an inch diameter, to be introduced through the wooden pipe described above, into the stratum of marl at the bottom of the well, so as to stand about three feet above the surface of the ground. Near the bottom of this leaden pipe was sewed, between two leaden rings or flanches, an inverted cone of stiff leather, into which some wool was stuffed to stretch it out, so that, after having passed through the wooden pipe, it might completely fill up the perforation of the clay. Another leaden ring or flanch was foldered round the leaden pipe, about two yards below the surface of the ground, which, with some doubles of flannel placed under it, was nailed on the top of the wooden pipe, by which means the water was perfectly precluded from rising between the wooden and the leaden pipes.

This being accomplished, the bottom of the well remained quite dry, and the new water quickly rose about a foot above the top of the well in the leaden pipe; and, on bending the mouth of this pipe to the level of the surface of the ground, about two hogheads of water flowed from it in twenty-four hours, which had similar properties with the water of St. Alkmund's well, as on comparison both these waters curdled a solution of soap in spirit of wine, and abounded with calcareous earth, which was copiously precipitated by a solution of fixed alkali; but the new water was found to possess a greater abundance of it, together with numerous small bubbles of ærial acid or calcareous gas.

The new water has now flowed about twelve months, and, as far as I can judge, is already increased to almost double the quantity in a given time; and from the rude experiments I made, I think it is now less replete with calcareous earth, approaching gradually to an exact correspondence with St. Alkmund's well, as it probably has its origin between the same strata of earth.

As many mountains bear incontestible marks of their having been forcibly raised up by some power beneath them; and other mountains, and even islands, have been lifted up by subterraneous fires in our own times, we may safely reason on the same supposition in respect to all other great elevations of ground. Proofs of these circumstances are to be seen on both sides of this part of the country; whoever will inspect, with the eye of a philosopher, the lime-mountain at Breedon, on the edge of Leicestershire, will not hesitate a moment in pronouncing, that it has been forcibly elevated by some power beneath it; for it is of a conical form, with the apex cut off,
and

and the strata, which compose the central parts of it, and which are found nearly horizontal in the plain, are raised almost perpendicularly, and placed upon their edges, while those on each side decline like the surface of the hill; so that this mountain may well be represented by a bur made by forcing a bodkin through several parallel sheets of paper. At Rouster, or Eagle-stone, in the Peak, several large masses of grit-stone are seen on the sides and bottom of the mountain, which by their form evince from what parts of the summit they were broken off at the time it was elevated; and the numerous loose stones scattered about the plains in its vicinity, and half buried in the earth, must have been thrown out by explosions, and prove the volcanic origin of the mountain. Add to this the vast beds of toad-stone or lava in many parts of this county, so accurately described, and so well explained, by Mr. WHITEHURST, in his Theory of the Formation of the Earth.

Now as all great elevations of ground have been thus raised by subterraneous fires, and in a long course of time their summits have been worn away, it happens, that some of the more interior strata of the earth are exposed naked on the tops of mountains; and that, in general, those strata, which lie uppermost, or nearest to the summit of the mountain, are the lowest in the contiguous plains. This will be readily conceived if the bur, made by thrusting a bodkin through several parallel sheets of paper, had a part of its apex cut off by a pen-knife, and is so well explained by Mr. MICHELL, in an ingenious paper on the Phænomena of Earthquakes, published a few years ago in the Philosophical Transactions.

And as the more elevated parts of a country are so much colder than the vallies, owing, perhaps, to a concurrence of

two or three causes, but particularly to the less condensed state of the air upon hills, which thence becomes a better conductor of heat, as well as of electricity, and permits it to escape the faster; it is from the water condensed on these cold surfaces of mountains, that our common cold springs have their origin; and which, sliding between two of the strata above described, descend till they find or make themselves an outlet, and will in consequence rise to a level with the part of the mountain where they originated. And hence, if by piercing the earth you gain a spring between the second and third, or third and fourth stratum, it must generally happen, that the water from the lowest stratum will rise the highest, if confined in pipes, because it comes originally from a higher part of the country in its vicinity.

The increasing quantity of this new spring, and its increasing purity, I suppose to be owing to its continually dissolving a part of the earth it passes through, and hence making itself a wider channel, and that through materials of less solubility. Hence it is probable, that the older and stronger springs are generally the purer; and that all springs were originally loaded with the soluble impurities of the strata, through which they transuded.

Since the above-related experiment was made, I have read with pleasure the ingenious account of the King's wells at Sheerness, in the last volume of the Transactions, by Sir Thomas Hyde Page, in which the water rose three hundred feet above its source in the well; and have also been informed, that in the town of Richmond, in Surrey, and at Inship near Preston in Lancashire, it is usual to bore for water through a lower stratum of earth to a certain depth; and that when it

is found at both those places, it rises so high as to overflow the surface of the well : all these facts contribute to establish the theory above-mentioned. And there is reason to conclude, that if similar experiments were made, artificial springs, rising above ground, might in many places be thus produced at small expence, both for the common purposes of life, and for the great improvement of lands by occasionally watering them.

